List of Claims

1. (previously presented) A fuel injector comprising:

an injector body defining an unrestricted path and a restricted rate shaping path that includes a guide bore and a planar valve seat;

a moveable intensifier piston, when in a retracted position, including a first hydraulic surface and a second hydraulic surface, and the first hydraulic surface being exposed to hydraulic pressure in the unrestricted path and the second hydraulic surface being exposed to hydraulic pressure in the restricted rate shaping path; and

a variable flow rate valve member being guided to move within the guide bore between a first position and a second position, defining a first passage with a predetermined flow area and including a side surface separating a closing hydraulic surface from an opening hydraulic surface, and the side surface including a plurality of guide surfaces separating second passages.

2. (original) The fuel injector of claim 1 including a spring operably positioned to bias the variable flow rate valve member toward the planar valve seat.

3. (original) The fuel injector of claim 1 wherein the variable flow rate valve member includes three guide surfaces.

4. (original) The fuel injector of claim 1 wherein the plurality of guide surfaces being segments of a cylinder wall.

5. (original) The fuel injector of claim 1 wherein the variable flow rate valve member includes a transition surface being free of right angles and being positioned between the closing hydraulic surface and the side surface.

6. (original) The fuel injector of claim 1 wherein the closing hydraulic surface and the opening hydraulic surface having identical effective areas, and including parallel surfaces.

7. (previously presented) The fuel injector of claim 1 wherein the variable flow rate valve member separates the restricted rate shaping path into a first portion that extends between a flow control valve and the variable flow rate valve member and a second portion that extends between the variable flow rate valve member and the second hydraulic surface of the intensifier piston; and

the first portion of the restricted rate shaping path includes third and fourth opposing passages merging in an equalizer chamber.

8. (previously presented) The fuel injector of claim 1 wherein the variable flow rate valve member separates the restricted rate shaping path into a first portion that extends between a flow control valve and the variable flow rate valve member and a second portion that extends between the variable flow rate valve member and the second hydraulic surface of the intensifier piston; and

the first portion of the restricted rate shaping path includes a plurality of equalizer passages that fluidly connect an equalizer chamber to the first passage and the second passages of the variable flow rate valve member.

9. (original) The fuel injector of claim 8 wherein the plurality of equalizer passages include at least four peripheral equalizer passages positioned around a circumference of an equalizer center passage.

10. (previously presented) The fuel injector of claim 9 including a spring operably positioned to bias the variable flow rate valve member towards the planar valve seat;

the variable flow rate valve member includes three guide surfaces being segments of a cylinder wall;

the closing hydraulic surface and the opening hydraulic surface of the variable flow rate valve member being identical surfaces and include parallel surfaces, each surrounded by a bevel; and

the first portion of the restricted rate shaping path includes third and fourth opposing passages merging in the equalizer chamber.

11. (previously presented) A fuel injection system comprising:

a source of actuation fluid;

a source of fuel;

a fuel injector including an injector body defining an actuation fluid inlet being in fluid communication with the source of actuation fluid, a fuel inlet being in fluid communication with the source of fuel, an unrestricted path, and a restricted rate shaping path that includes a guide bore and a planar valve seat; a moveable intensifier piston, when in a retracted position, including a first hydraulic surface and a second hydraulic surface, and the first hydraulic surface being exposed to hydraulic pressure in the unrestricted path and the second hydraulic surface being exposed to hydraulic pressure in the restricted rate shaping path; and a variable flow rate valve member being guided between a first and second position within the guide bore and defining a first passage with a predetermined flow area and including a side surface separating a closing hydraulic surface from an opening hydraulic surface, and the side surface including a plurality of guide surfaces separating second passages.

12. (original) The fuel injection system of claim 11 including a spring operably positioned to bias the variable flow rate valve member toward the planar valve seat.

13. (original) The fuel injection system of claim 12 wherein the actuation fluid being different than the fuel.

14. (currently amended) A method of operating a fuel injector comprising the steps of:

slowing an advancement rate of an intensifier piston over a portion of the intensifier piston advancement, at least in part, by restricting, via a first passage of a variable flow rate valve, a flow area of a rate shaping path relative to a flow area of an unrestricted intensifier path;

unrestricting, via second passages of the variable flow rate valve, the flow area of the rate shaping path during the intensifier piston retraction relative to the flow area of the rate shaping path during the intensifier piston advancement; and

reducing variable flow rate valve wear, at least in part, by guiding a variable flow rate valve member along guide bore walls within the rate shaping path.

15. (original) The method of claim 14 wherein the step of reducing includes a step of biasing the variable flow rate valve member with a spring into contact with a planar valve seat.

16. (original) The method of claim 14 wherein the step of reducing includes a step of reducing cavitation within the rate shaping path, at least in part, by reducing the volume between the flow control valve and the variable flow rate valve member.

17. (original) The method of claim 14 wherein the step of reducing includes a step of breaking corners of the variable flow rate valve member.

18. (original) The method of claim 14 wherein the step of reducing includes a step of stabilizing the variable flow rate valve member, at least in part, by distributing hydraulic pressure over a closing hydraulic surface of the variable flow rate valve member.

19. (original) The method of claim 18 wherein the step of distributing includes a step of dividing a hydraulic flow into a plurality of passages prior to acting on the closing hydraulic surface.

20. (original) The method of claim 19 wherein the step of reducing includes the steps of biasing the variable flow rate valve member with a spring into contact with a planar valve seat, breaking corners of the variable flow rate valve member, and reducing cavitation within the rate shaping path, at least in part, by reducing the volume between the flow control valve and the variable flow rate valve member.